A Quantitative Approach to Geodesign Process Analysis

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Abstract: The paper proposes a new approach to Geodesign Process Analytics (GDPA) based on the use of geodesign workshop log-data gathered by web-based collaborative the Planning Support System Geodesignhub. As argued in the paper, the analysis and mining of PSS log-data enable the coordinator of a geodesign study to gain better insights into the evolution of design during the process as well as about the process dynamics. While the research is still in its early stage, first results show a huge potential for the practical application of GDPA in workshop coordination support, in gaining insights about past geodesign processes, and in understanding social behaviour in the design process dynamics.

Keywords: Geodesign, process analytics

1 Introduction

Geodesign can be thought of both as a verb and as a noun (STEINITZ 2012), or in other words as a process and as a product of that process. Thus, understanding geodesign, learning from past and on-going experiences, and assessing its value require dealing with the complexity of its twofold meaning, as both the quality of the product and of the unfolding of the process should be critically considered. Such an investigation may be useful both for learning from past case studies with the aim of improving future ones, and for monitoring ongoing processes dynamically. While the experience and the observation skills of those involved in the coordination of geodesign studies will always be critical, the actual availability of new digital cockpits monitoring the process and its product real-time may potentially add substantial value, especially in fast-pace intensive geodesign workshops.

Recent advances in Computer Aided Design (CAD), Building Information Modelling (BIM) and Planning Support Systems (PSS), are nowadays enabling collaboration within increasingly complex workflows in planning and design. Such technologies are currently able to store data about the evolution of the design product, as earlier technology (e. g., CAD, GIS and geo-databases), but also log-data about the interaction of multiple users collaborating in collective design endeavours with the supporting digital platform (REVIT 2019, SOLIDWORKS 2016). As such, log-data can be readily made available to coordinators to monitor the process, including the temporal sequence of activities and tasks, the user behaviour and productivity, and the evolution of the design in space and time. The opportunity of analysing this new type of data with digital dashboards may potentially enable the application of a sort of business intelligence perspective in real-time geodesign study coordination and management, and in retrospective or comparative studies, by mining what may be considered geodesign (processes) big-data. To date, early research in this direction was successfully undertaken in several close domains such as industrial design, architecture and construction engineering (BECATTINI et al. 2019, ZHANG et al. 2018, ZHANG & ASHURI 2018), but similar attempts in geodesign are still at a very early stage. The collaborative PSS Geodesignhub started to offer simple measure about ongoing geodesign workshops. However, a wider and

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more robust Geodesign Process Analytics (GDPA) is needed to fulfil the potential offered by geodesign process log-data.

This contribution summarizes the results obtained so far in an ongoing research carried on by the authors (COCCO et al. 2019, COCCO et al. 2020) aiming at defining an operational analytical framework for analysing planning and design processes. The new source of data, that is log-data gathered digitally during geodesign workshops thanks to the functionalities of Geodesignhub, were used to operationally test the hypothesis. Specifically, the log-data were originated in a geodesign workshop carried on by the authors under the umbrella of the International Geodesign Collaboration (IGC) (ORLAND & STEINITZ 2019).

The results show how it is possible to apply descriptive and inferential statistics to monitor the process real-time through e-dashboards in which a variety of indicators is implemented considering the semantics macro-dimensions of log-data which include design, authorship, space, and time.

2 Towards a Geodesign Process Analysis

A major challenge in collaborative geodesign, and in spatial planning in general, is not only to reach consensus towards a final plan, but also to make the process transparent to all the users, including those who participate to the design process but also those who eventually will have to implement the plan or will be affected by the plan implementation. Transparency of the process is of utmost importance both to understand how to react in case of unexpected issues during the plan implementation, but also to acquire better knowledge of the dynamics underlying the process which may serve as experience for the future. In other words, understanding how the process dynamics (may) affect the design outcome (Figure 1) is a sensitive issue.

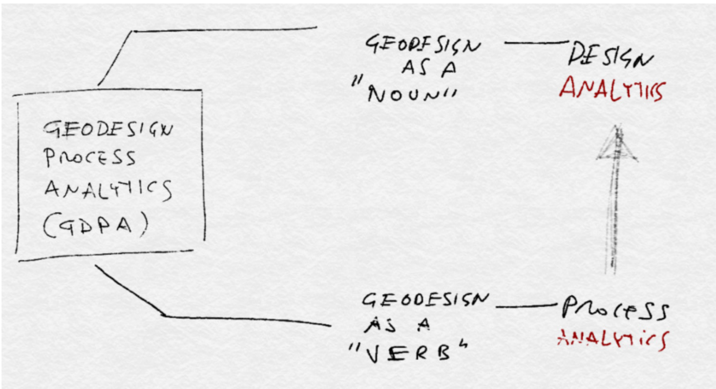

Fig. 1: General framework for a geodesign process analytics

In order to address the complexity of current planning processes, PSS log-data may offer a very useful aid. Such PSS as Geodesignhub, store a great quantity of data during the process, not only about the design products, but also about the process itself. Even in a single workshop, a rich database of log-data is generated and made available for analysis, during or after the workshop.

Two approaches are possible to analyses geodesign process log-data: the first is data-driven, the second theory-driven. Both approaches were tested by the authors, before applying GDPA to earn practical insights about a specific case-study. The former two approaches were used iteratively to get preliminary insights on the potential value of using log-data to understand geodesign process and their relationships with their outcome, that is the final design.

Following these preliminary results, a framework for geodesign process analytics was shaped by developing a series of indicators to measure and understand design dynamics (Figure 2). The analytics tool covers two types of measures: those linked to the actions of the participants which characterize the process (e. g., participants' performance indicators, temporal indicators, indicators of design evolution), and those related to design aspects of the products (e. g., spatial indicators). For example, the first set of indicators allows the assessment of the achievement of certain performance (/participation) levels (e. g., number of times a participant used the sketching tool in a collaborative PSS, identify leading/lagging behind participants), and analysis of spatial relations (e. g., topology, proximity) between design alternatives proposed by different groups of stakeholders to easily identify areas of disagreement, which may help to reach consensus among planning stakeholders.

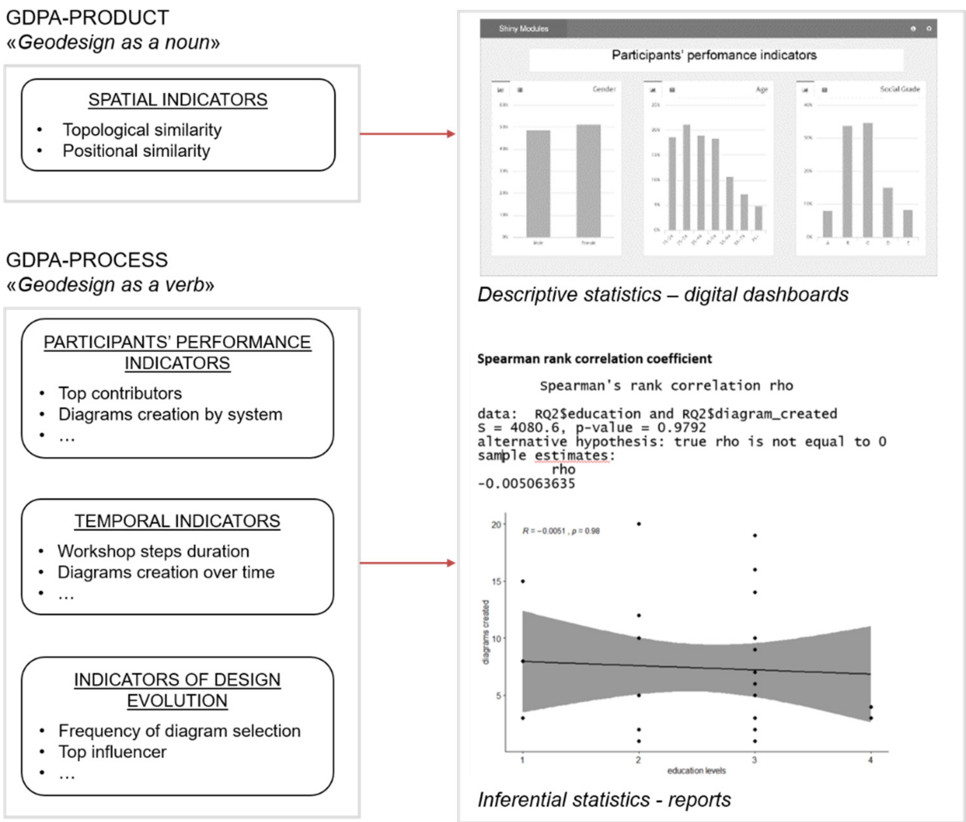

Fig. 2: Geodesign Process Analytics

Descriptive and inferential statistics were applied to construct the indicators proposed in this study (Figure 2). Some of them are more suitable to support the coordinator in real-time, and some other to be used in a post-workshop de-briefing to analyze the design process in itself and in comparisons with other studies. It is argued, investigating these aspects can increase the coordinator understanding of the process, which may, in turn, lead to improve the design outcomes, as well as, future processes. In order to demonstrate the research assumptions, the web-based PSS Geodesignhub has been used since it allows stakeholders to effectively contribute in the last three models (i. e., change, impact and decision models) of a geodesign process (STEINITZ 2012), and it records log-data about the whole process with regards to design and to the actions of the involved actors.

2.1 The Data-Driven Approach

The data-driven approach starts with the exploratory analysis of geodesign workshops log-database. Geodesignhub grants full access to its log-data via API. Then, data can be arranged in a spatial-temporal database. Figure 3 shows the conceptual model of a Geodesignhub log-database.

Analysing the thematic, spatial and the temporal (along the process timeline) dimensions of design versions together with the user dimension is it possible to unfold the link between the process and its outcomes.

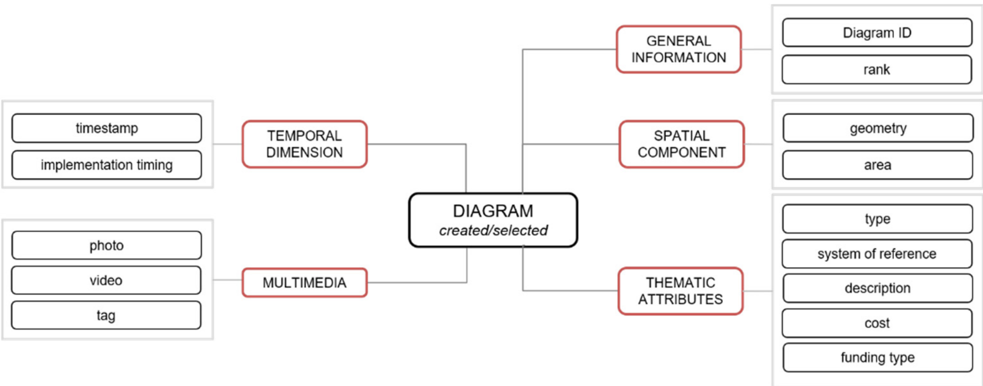

Fig. 3: Conceptual model of a Geodesignhub log-database

The example in Figure 4 shows an example of a dynamic e-dashboard which allows monitoring the performance of the participants during a geodesign workshop. The indicators presented in the e-dashboard in figure 3 are just an example of measures of a typical geodesign process that can be calculated and visualized real-time to support the workshop coordinator in assisting the participants and make informed decisions as are needed to improve the current process. These and other indicators can be used also to analyse different workshops in ex-post process evaluation and comparative analysis. The value of the single indicator in general should be contextualized by the coordinator in the face of the process dynamics at hand. In visualizing the indicators in an e-dashboard, there is potential for providing useful tools for design process log-data mining, providing a sort of design process intelligence, much like business intelligence is proficiently applied in industry (VAN DER AALST 2011, VAN DER AALST et al. 2012, COCCO et al. 2020).

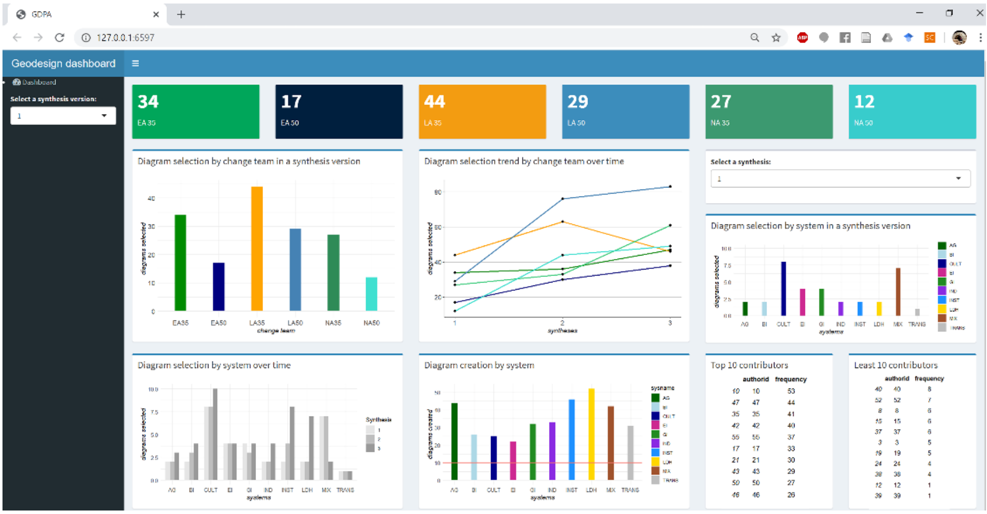

Fig. 4: Geodesign Process analytics: example of e-dashboard

2.2 The Theory-driven Approach

Unlike the log-data-driven approach, which relies mostly on descriptive statistic in an exploratory way, the theory-driven approach may use inferential statistics to validate theoretical assumptions or construct. COCCO et al. (2019) applied inferential statistic to test the value of using log-data as a complementary source of information, to more traditional process recording methods (e. g., notes, video recordings, interviews, etc.) in the application of the Enhanced Adaptive Structuration Theory (EAST2) by JANKOWSKI and NYERGES (2001). EAST2 was used as theoretical framework to guide the identification of interesting dynamics to be investigated in comparative studies. A series of hypotheses were formulated and tested to explore the dynamics of participation and interaction among stakeholders involved in a computer-mediated collaborative planning and design process. The 'ways of designing' may differ among groups and individuals, and with varying scale and size of the area. Therefore, breaking down the digital workflow and using quantitative measures to identify recurrent patterns in participants' behaviours and design evolution may help better design and manage future geodesign processes, as required by the meta-planning approach.

2.3 The Mixed Applied Approach

The mixed-applied approach was used by the authors to investigate the relationships between the green infrastructure and the other territorial systems design in a geodesign workshop. Of particular interest is the contribution of the spatial indicators which allow to easily identify possible conflicts of interest. The proposed methodology involved the use of traditional spatial analysis techniques, together with the design topology analysis developed with Extract Transform Load (ETL) software as proposed by FREITAS and MOURA (2018), and of other GDPA techniques developed by the authors. The study provided a systematic and quantitative demonstration of how geodesign techniques and PSS log-data analysis can be successfully used to integrate the green infrastructure design within broader in scope strategic comprehensive territorial planning. The use of spatial and statistical analysis allowed to measure quantitatively several aspects of the design process highlighting the fundamental relationship between green infrastructure and the other territorial development systems and dynamics.

3 Discussion

This paper summarizes the effort undertaken to improve our understanding of design processes and develop a methodology to analyze geodesign studies by exploiting the data automatically recorded by a web-based collaborative PSS. The opportunities offered by current PSS are unprecedented, not only for applying a system approach and coordinating involved actors, but also for tracking the evolution of the design options toward the final plan. The availability of process log-data in Geodesignhub opens new paths to the understanding of design dynamics. With the aim of making the value of the new data source, the analytical process towards GDPA is proposed from log-data extraction and pre-processing methods and tools, to the development of the set of spatial, temporal, user performance and design evolution indicators.

It is demonstrated how the proposed measures are suitable to be displayed in a dynamic dashboard making available a real-time process analysis tool to the workshop conductor, thus supporting their core role of facilitating the process. While the indicators have not yet been tested in a real-time case study, an *ex-post* implementation of the geodesign analytics has been explored using the log-data recorded in the Cagliari geodesign study developed within the IGC project.

Additionally, inferential statistical techniques were applied to log-data of past geodesign studies to elicit and reveal relationships and patterns in participant behaviour and in the evolution of the design, ultimately aiming at better understanding, assessment, design and management of past/future processes.

Finally, the use of geodesign and geodesign process analytics are respectively proposed as a holistic and systematic approach and as a user-friendly analytical tool to support integrate and collaborative green infrastructures planning. Their implementation in digital dashboard provides an efficient tool for understanding how systems mutually influence each other in rapid real-time design iterations.

4 Conclusion and Outlook

Early findings suggest a huge potential for making value of available log-data for earning new insights about the collaborative design generation and about the social and behavioural aspects of design process dynamics. On the basis of the experimental findings, it is possible to confirm that the use of current digital tools, compared to traditional ways of recording or tracking the process workflow (i. e., video recordings, surveys), makes available for analysis a greater number of aspects and dimensions, thus contributing to the grasping of many facets of the complex design dynamics in a systematic fashion. Further research is definitely needed to define a robust geodesign process analytics, possibly leading to a better understating of general patterns and behaviours in planning and design processes. Nevertheless, the proposed analytical framework offers the possibility in the short-medium term, not only to make past process more transparent, but also to monitor ongoing processes real-time assembling process performance indicators in digital dashboards. If this approach yields the expected fruits, it may eventually contribute to gathering new knowledge useful for the design of future collaborative planning and design initiatives through metaplanning (CAMPAGNA 2016).

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